Applying Innovative Frameworks to Foster Inclusive Learning in Engineering Students

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***Abstract* – This special session is based on work we are undertaking in our NSF-funded Revolutionizing engineering and computer science Departments (RED) project. We will share our innovative and ongoing efforts to construct an inclusive curriculum, motivated by two goals: to help students develop their knowledge, skills and dispositions to engineer inclusively and to embed inclusive practices in our department, courses, and research labs. Participants will be exposed to new ways to think about, measure, and increase inclusion in engineering departments, classrooms, and research labs. This workshop is intended for a broad audience of engineering educators (e.g., faculty, academic advisors, curriculum designers, instructional developers, etc.). Given the breadth and importance of interpersonal interactions that engineers encounter in their educational and professional careers, the topics central to this session are of significance to engineering education. Material for this session is based on our NSF-funded project, Transforming for Inclusion: Fostering Belonging and Uniqueness in Engineering Education and Practice.[1]**

Keywords—education, inclusion

I. INTRODUCTION

How can we prepare engineers who both value inclusion and are comfortable and skilled at being inclusive? In the quest to prepare engineers for an increasingly diverse work environment, we are challenging ourselves and our colleagues to iteratively update our approach. Diversity is widely understood as a desired aspect of the engineering profession (Pawley, 2017) and is an enacted value within our department. Inclusion, however, has been elusive. Despite concerted efforts, our recent departmental climate survey revealed that some still students—largely, women, people of color, older students, and transfer students—do not feel included. We are working to change that by innovating and implementing changes in our pedagogical approaches with the ambitious objective of sparking departmental transformation and, eventually, disciplinary transformation. This session shares some of the theories and techniques we are using to develop inclusive engineers. Participants will be challenged to consider the utility of these theories and techniques to the future of engineering education and the profession overall.

II. RATIONALE

Academia has largely been deemed responsible for ensuring that students master the behaviors and skills considered necessary to function successfully in the workplace. Recent inquiries into this expectation placed on academics has confirmed that this the expectation persists; we believe that the skills and experiences we are infusing into our department and instilling in our students is a viable pathway to meeting this expectation and preparing students for the increasingly diverse workplace. One such recent inquiry was the American Society for Engineering Education’s (ASEE) Transforming Undergraduate Education in Engineering (TUEE) project.

Phase I of TUEE commissioned representatives of industry and academia “to produce a clear understanding of the qualities engineering graduates should possess and to promote changes in curricula, pedagogy, and academic culture needed to instill those qualities in coming

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generations of engineers" (ASEE, 2013, p. 2). The outcome was a list of 36 Knowledge, Skills, and Abilities (KSAs) deemed integral to the profession, and an indication of which stakeholders—the students themselves, parents, academics, industry professionals, or some combination of these—should bear most responsibility for ensuring that engineers have mastered these KSAs. While Phase I participants believed that academia was responsible for ensuring that students master the fundamentals of the field and the ability to identify, formulate, and solve engineering problems, they also gave academia chief responsibility (sometimes shared with parents or industry) to train students in communication, critical thinking, and teamwork (ASEE, 2013).

Interestingly, in Phase II of the TUEE project, 41 engineering students and recent graduates were asked to collectively rank the 36 KSAs developed in Phase I; they ranked communication, critical thinking, and teamwork as very important, noting that their personal prioritization of these skills was not matched by their institutions (ASEE, 2017). In short, representatives of industry, academic programs, and students all agree that communication and teamwork are essential to engineering education. Further, industry and academic representatives believe that engineering educators bear responsibility for helping students develop these skills. We have undertaken this charge in our work with biomedical engineering students and will use this special session to review our progress, while also introducing theories and practices have employed We will solicit feedback on the usefulness of these frameworks for engineering education.

III. Topics and Content of the Session

The three frameworks central to our session are: Chi and Wylie's (2014) ICAP Framework, Caporael's (1995) core configuration model (CCM), and Brewer's (1991) Optimal Distinctiveness Theory (ODT). The ICAP Framework categorizes students' overt classroom behaviors into four modes—interactive, constructive, active, or passive—that serve as indicators of their cognitive engagement. Chi and colleagues have shown that as students become more engaged with the learning materials their learning increases. We introduce the ICAP framework to our students to help them understand why we create classroom settings that promote interactive engagement. Likewise, in this session, we will leverage the ICAP Framework as a tool to focus session participants on their own engagement in the session and on the types of solutions they propose for intervening in classroom scenarios. Interestingly, though, we have found that creating a classroom environment that promotes interactive engagement is not sufficient. Students must also learn to interact with each other inclusively in order to realize the full benefit of engaging interactively with each other.

ODT and the CCM help us understand how to help students interact inclusively. ODT is a framework for understanding the tension people feel between needing to belong while at the same time needing to be valued for, and free to be, their unique or authentic selves. Studies have demonstrated that motivations are strong to maintain optimal satisfaction in both areas. Thus, for us and others, inclusion can be understood and measured by the degree to which an individual feels they are an esteemed and valued member of a group.

The CCM helps us understand the dynamics of social systems by showing that four core configurations repeatedly form in any human social system: dyads (two people), teams (about five people), demes (about 30 people), and macrodemes (about 300 people). Humans have the capacity to coordinate their activities with others within each of these configurations, but these skills take time to develop. In applying the CCM perspective to our situation, we recognize that whether or not students feel optimally distinct is a function of the constellation of social interactions that take place each day within each of these four core configurations or social scales. To achieve our vision, we must equip our students and faculty with the knowledge, skills and dispositions act inclusively at all four social scales.

These frameworks illuminate the socio-affective nature of inclusion. Social interactions at the dyad, team, deme or macrodeme levels can signal inclusion or exclusion, which, in turn, cascade into positive feelings of belonging and authenticity or, through microinequities, can lead to feelings of exclusion and rejection. Participants will be introduced more fully to each of the theoretical frameworks explained above, and given tasks to complete within an engineering education context while interacting on varying social scales.

IV. Outline of the Session Activities and Learning Outcomes

Upon assembling, session participants will be introduced to our project to transform engineering education for inclusion. Following an introduction to the RED project, the session will be divided into three segments to introduce participants to the theoretical frameworks. Throughout the session, participants will be challenged to meaningfully interact with the frameworks by engaging each other in a series of activities that occur on varying social scales and reflecting on how these frameworks might influence their teaching approaches and research lab leadership practices.

A. *Segment 1: Interaction Modes within the Learning Environment* [10 minutes]

Student interactions within a department occur at four levels: dyads (two people), teams (~5 people), demes (~30), and macrodemes (~300; Caporael, 1995). We have conceptualized these levels as existing within our department as student pairs and project teams within courses, a full classroom (the deme), and the entire department (the macrodeme). Students are likely to feel fully included when their experiences at all these levels contribute to them feeling both a sense of belonging and the freedom to be their authentic selves (that is, to them feeling optimally distinct). Educators must therefore consider how norms and practices at each social scale facilitate or inhibit belongingness and authenticity.

Within a class, students can also experience four modes of cognitive engagement: interactive, constructive, active, and passive (Chi & Wylie, 2014). This four-part schema is termed the ICAP Framework. Educators must consider how to increase the time students spend in the more dynamic modes of engagement, where inclusiveness can be maximized.

We will introduce the ICAP Framework as the first segment, in order to include it as part of the ground rules for our session and set the expectation that everyone will avoid passive participation in this session.

After this segment, participants will be prepared to:

- describe group size as a contributor to how students interact and perceive inclusion
- recognize different engagement levels

B. *Segment 2: Inclusion and Optimal Distinctiveness* [25 minutes]

Next, participants will be introduced to the components of inclusion that we have begun to investigate in departmental courses. We will introduce participants to optimal distinctiveness theory (ODT). A self-report scale to measure inclusion through the lens of ODT has been developed and tested by others for convergent and discriminant validity (Jansen, Otten, Van der Zee, & Jans, 2014). Scale items are as follows:

This group…

1. …gives me the feeling that I belong
2. …gives me the feeling that I am part of this group
3. …gives me the feeling that I fit in
4. …treats me as an insider
5. …likes me
6. …appreciates me
7. …is pleased with me
8. …cares about me
9. …allows me to be authentic
10. …allows me to be who I am
11. …allows me to express my authentic self
12. …allows me to present myself the way I am
13. …encourages me to be authentic
14. …encourages me to be who I am
15. …encourages me to express my authentic self
16. …encourages me to present myself the way I am

We will introduce this scale to participants and share examples of how students' efforts to seek optimal distinctiveness may show up, or be facilitated in, engineering classrooms.

Activity: In dyads, participants will be tasked to solidify their understandings of the two aspects of optimal distinctiveness: belonging and authenticity. Each person will take turns explaining their definition of each concept and having their partner repeat, in their own words, what they heard and how their understanding may differ.

After this segment, participants will be able to:

- define inclusion and describe how it relates to their classroom experiences
- explain how to measure inclusion
- summarize the importance of optimal distinctiveness to the student experience

C. *Segment 3: Working in Teams, Demes, and Macrodemes* [30 minutes]

Joining three dyads together to form a team, the team will be tasked to design at least two potential classroom activities to promote inclusion. Participants may elect to create a novel activity or to modify a learning activity that they already assign to be more inclusive by; the latter can be achieved by making the activity more interactive (per ICAP), paying attention to the predominant social scale in which interactions are taking place (per CCM), and working to ensure that the activity promotes students' sense of belonging and/or authenticity.

Participants will then review and critique the work of other teams. This will allow each team to receive diverse perspectives on the positive and negative attributes of their work.

After this segment, participants will be prepared to:

- design activities that promote inclusion within varying modes of engagement and at levels of interaction
- critique activities designed to promote inclusion

V. Assessing the Experience

With our remaining time together (~15 minutes), participants will be asked to take 5 minutes to each review the Perceived Group Inclusion Scale (items shared above), and encouraged to mentally complete the scale based on their recent group experience in the session. As a large group—deme or macrodeme, depending on how many people attend the session—we will process the recent group experience, the Perceived Group Inclusion Scale, and the development of belongingness and authenticity in the classroom.

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